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**Demographic Demand Systems with Application to
Equivalence Scales Estimation and Inequality Analysis:
The Australian Evidence**

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# DEMOGRAPHIC DEMAND SYSTEMS WITH APPLICATION TO EQUIVALENCE SCALES ESTIMATION AND INEQUALITY ANALYSIS:

## THE AUSTRALIAN EVIDENCE*

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**ABSTRACT**


This paper proposes and applies an alternative demographic procedure for extending a demand system to allow for the effect of household size and composition changes, along with price changes, on expenditure allocation. The demographic procedure is applied to two recent demand functional forms to obtain their estimable demographic extensions. The estimation on pooled time series of Australian Household Expenditure Surveys yields sensible and robust estimates of the equivalence scale, and of its variation with relative prices. Further evidence on the usefulness of this procedure is provided by using it to evaluate the nature and magnitude of the inequality bias of relative price changes in Australia over a period from the late 1980s to the early part of the new millennium.

# 1. INTRODUCTION

Demand systems are, traditionally, derived from a priori specified individual utility functions that assume individual utility maximising behaviour subject to her/his budget constraint. This posed a problem in empirical applications since individuals reside in households and the household, rather than the individual, is the unit of behaviour. Moreover, the data set is, typically, available at the household level, necessitating the incorporation of household size and composition variables, along with prices and aggregate expenditure, as determinants of demand. While the earlier studies on the impact of household size and composition changes on expenditure patterns were ad hoc [see, for example, Prais and Houthakker (1955)] and ignored temporal price variation, being based on a single cross section, Barten (1964)'s introduction of household utility models allowed the specification and estimation of utility-consistent demographic demand systems [see Pollak and Wales (1992), especially Ch. 3].

The demographic generalisation of conventional demand systems, while providing a superior analysis of expenditure patterns, also, allows a wide variety of policy applications ranging from the estimation of equivalence scales to the design of taxes. The chief motivation of this paper is to explore the policy usefulness of demographic demand systems by using the estimated demand parameters in selected policy applications. This paper proposes two alternative demographic demand systems and illustrates their policy usefulness in calculating equivalence scales and in assessing the impact of prices on expenditure inequality.

This study is based on the demographic generalisation of two recent demand models, namely, the Quadratic Almost Ideal Demand System (QAIDS) [see Banks, Blundell and Lewbel (1997)] and the Modified Almost Ideal Demand System (MAIDS) due to Cooper and McLaren (1992). Both these demand systems extend the Almost Ideal Demand System (AIDS), due to Deaton and Muellbauer (1980), to allow more flexible price and Engel responses. However, while QAIDS is a rank 3 demand system with independent price and income coefficients and allows non-monotonic relationship between the budget share of an item and household expenditure, MAIDS retains the rank 2 feature of AIDS and imposes a monotonic relationship. However, as Cooper and McLaren (1992, p.652) show, MAIDS "preserves regularity in a wider region of expenditure price space" than AIDS.

The present study uses different demographic techniques on these demand systems to obtain their demographic generalisations in estimable form. This sets up an interesting comparison between the estimates of the basic demand parameters and of the equivalence scales from the

alternative demands systems. The paper also highlights the policy usefulness of the demographically extended QAIDS by using the parameter estimates to assess the impact of price movements on expenditure inequality.

The study is carried out on unit records contained in Australian Household Expenditure Surveys (HES) pooled over a period of nearly 15 years. The choice of the data set generates interest in the findings since the period covered includes a brief period of recession followed by an uninterrupted period of low unemployment, high growth rates, GST changes and overall economic prosperity. Australia is, thus, often cited as a model example among the developed countries.

The plan of this paper is as follows. Section 2 derives the demographic demand models. Section 3 describes the data, presents the demographic demand estimates and compares the Engel curves implied by the alternative demographic demand models. The evidence on the impact of price changes on inequality is presented in section 4. The paper ends on the concluding note of section 5.

## 2. THE DEMOGRAPHIC DEMAND SYSTEMS

In non demographic form, the cost function of QAIDS is given, in logarithmic form, by

$$\ln c\,(u,p) = \ln a(\mathbf{p}) + \frac{ub(\mathbf{p})}{1 - uc(\mathbf{p})} \tag{1}$$

where $a(\mathbf{p})$ is homogenous of degree 1 in prices, $\mathbf{p}$, $b(\mathbf{p})$ and $c(\mathbf{p})$ are homogenous of degree 0 in $\mathbf{p}$. The choice of the following functional forms for $a(\mathbf{p})$, $b(\mathbf{p})$ and $c(\mathbf{p})$ yields the QAIDS.

$$\ln a(\mathbf{p}) = \alpha_0 + \sum_k \alpha_k \ln p_k + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \tag{2a}$$

$$b(\mathbf{p}) = \prod_k p_k^{\beta_k} \tag{2b}$$

$$c(\mathbf{p}) = \prod_k p_k^{\lambda_k} \tag{2c}$$

$$\sum_k \alpha_k = 1, \ \sum_k \beta_k = \sum_i \gamma_{ij} = \sum_k \lambda_k = 0, \gamma_{ij} = \gamma_{ji}$$

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The price scaling (PS) technique, used to demographically extend the QAIDS, was introduced in Ray (1983). It stems from the definition of the general equivalence scale, $m_{0h}$, as the ratio of costs of obtaining a reference utility level, *u*, at a given vector of prices, **p**, of a household *h* with a demographic profile given by **z** and a reference household, *R*.

$$c_h(u, p, z) = m_{0h}(z, p, u) c_R(u, p) \tag{3}$$

If one specifies a suitable functional form for the cost function of the reference household, $c_R(u, p)$, which satisfies the usual economic theoretic conditions of linear homogeneity in prices, symmetry and concavity, then the choice of a suitable functional form for $m_{0h}(z, p, u)$[1] gives us the corresponding form for the cost function of household *h*. The latter yields, on application of Shephard's Lemma, the price scaled demographic demand equations.

As noted by Pollak and Wales (1979), utility dependent equivalence scales cannot be estimated from demand data. However, as Blackorby and Donaldson (1993) have shown, the assumption of the utility independence of the equivalence scale - $m_{0h}(z, p)$, allows the scale to be identified from budget data pooled across different time periods containing price variation[2].

We choose the following functional forms for the utility invariant general equivalence scale, $m_{0h}(z, p)$.

$$m_{0h}(z, p) = \prod_k p_k^{\delta_k z_h} (na_h + \sum_{g=1}^G \rho_g z_{gh})^{1-\theta} \tag{4}$$

where $\sum_k \delta_k = 0$

$na_h$ denotes the number of adults in household *h*, $z_{gh}$ denotes the corresponding number of children in age group *g*, $z_h (= \sum_{g=1}^G z_{gh})$ is the total number of children, $\rho_g$ is the age specific equivalence scale, $\delta_k$ measures the price sensitivity of the equivalence scale and $\theta$ denotes the household size economies of scale.

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[1] $m_{0h}(z, p, u)$ must be homogenous of degree 0 in prices for $c_h(u, p, z)$ to be homogenous of degree 1 in prices.
[2] See also Pendakur (2002).

The choice of (1), (2a)-(2c) as the cost function of the reference household, in conjunction with the price scaling (PS) demographic technique outlined above, yields the demographically extended QAIDS, to be referred to as PS-QAIDS. In budget share terms, $s_i$, is given as follows:

$$s_{ih} = \alpha_i + \delta_i z_h + \sum_j \gamma_{ij} \ln p_j$$

$$+ \beta_i [\ln x_h - \alpha_o - \sum_k \alpha_k \ln p_k - \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j - \theta \ln (n \alpha_h + \sum_{g=1}^{G} \rho_g z_{gh}) - \sum_k \delta_k z_h \ln p_k]$$

$$+ \lambda_i \prod_k p_k^{\lambda_k - \beta_k} [\ln x_h - \alpha_o - \sum_k \alpha_k \ln p_k - \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j - \theta \ln (n \alpha_h + \sum_{g=1}^{G} \rho_g z_{gh})$$

$$- \sum_k \delta_k z_h \ln p_k]^2 \tag{5}$$

where $x_h$ denotes the nominal expenditure of household $h$. In the estimations that are reported below, we set $\alpha_o$ a priori at zero. Note that (5) specialises to the non-demographic QAIDS if the demographic parameters, namely, $\delta_k$, $\rho_g$, $\theta$ are all zero. The conventional AIDS model is obtained as a further specialisation if $\lambda_i = 0$ for all $i$. Note, from (5), that the equivalence scale's price sensitivity parameter, $\delta_i$, can also be interpreted as the effect of the marginal child on the budget share of item $i$ for a household at subsistence level ($u=0$).

Unlike AIDS or QAIDS, the modified Almost Ideal Demand System (MAIDS), as introduced in Cooper and McLaren (1992), does not have an explicit representation of its cost or expenditure function. Consequently, the cost function based price scaling demographic technique cannot be applied in this case. An alternative demographic procedure that demographically modifies the utility function and retains the spirit of the PS in allowing price sensitivity of the equivalence scale is proposed in this case. In non-demographic form, the indirect utility function of MAIDS is given by:

$$U(x_h, p) = \ln \left( \frac{x_h}{P_1} \right) \left( \frac{x_h^{\eta}}{P_2} \right) \tag{6}$$

where (as before) $x_h$ denotes nominal expenditure of household $h$; $P_1$, $P_2$ are functions of prices, $p_i$ and are homogenous of degree 1 and $\eta$, respectively, in **p**. Equation (6), which is a

characterisation of MPIGLOG preferences, specialises to PIGLOG if $\eta = 0$. Note, also, that the demand systems generated by MPIGLOG preferences are members of the family of fractional demand systems discussed in Lewbel (1987).

The demographic extension of the MPIGLOG indirect utility form that we propose[3] involves replacing $x_h$ by $x_h^e = x_h / m_{0h}$, namely, the nominal expenditure per adult equivalent, where $m_{0h}$ [given by eqn. (4)] is the price dependent, but utility invariant, equivalence scale. The demographically modified MPIGLOG utility form is given by:

$$ u(x_h, z_h, p) = \ln\left(\frac{x_h}{m_{0h} \cdot P_1}\right)\left(\frac{x_h}{m_{0h}}\right)^{\eta}\left(\frac{1}{P_2}\right) = \ln\left(\frac{x_h}{P_{1h}^e}\right)\left(\frac{x_h^{\eta}}{P_{2h}^e}\right) \tag{7} $$

where

$$ P_{1h}^e = (n\alpha_h + \sum_{g=1}^{G} \rho_g z_{gh})^{\theta} \prod_k p_k^{\delta_k \cdot n} \cdot P_1 \tag{8a} $$

$$ P_{2h}^e = (n\alpha_h + \sum_{g=1}^{G} \rho_g z_{gh})^{\theta\eta} \prod_k p_k^{\delta_k \eta \cdot n} \cdot P_2 \tag{8b} $$

These equations above could be more easily be specified as:

$P_{1h}^{*} = m_h(\mathbf{p,z})P_1$ and $P_{2h}^{*} = (m_h(\mathbf{p,z}))^{\eta} P_2$ as $m_h(\mathbf{p,z})$ has already been specified.

The symbols are as defined before, and $\sum_k \delta_k = 0$. The application of Roy's identity to the indirect utility form, eqn. (7), yields the demographically modified MAIDS, to be referred to as the demographically modified MAIDS or DMMAIDS, as follows:

$$ s_{ih} = \frac{a_{1ih} + a_{2ih}R_h}{1 + \eta R_h} \tag{9} $$

where

$$ a_{1ih} = \frac{\delta \ln P_{1h}^e}{\delta \ln p_i}, \quad a_{2ih} = \frac{\delta \ln P_{2h}^e}{\delta \ln p_i}, \quad R_h = \ln\left(\frac{x_h}{P_{1h}^e}\right) $$

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[3] See Blacklow, Cooper, Ham and McLaren (2006) for an alternative demographic extension of MPIGLOG preferences.

Following the argument in Cooper and McLaren (1992, p. 658) for the non-demographic MAIDS, it is readily verified that in the region $x_h \gg P_{1h}^s$, the restrictions $a_{1ih} \geq 0$, $a_{2ih} \geq 0$ are sufficient to ensure that $0 \leq s_{ih} \leq 1$. This distinguishes the DMMAIDS from the PS-QAIDS which can imply estimated budget shares which lie outside the (0,1) interval.

Eqn.(9) shows that, for given prices, the budget share, $s_{ih}$, moves monotonically from $a_{1ih}$ for the 'poor' ( i.e. subsistence household) to $(a_{2ih}/\eta)$ for the 'rich'. Since $\epsilon_{1ih}$, $\epsilon_{2ih}$, which denote the $i^{th}$ price elasticities of $P_1^s$, $P_2^s$ respectively, will depend on the total number of children, $z_h$, via the $\delta_i$'s in (8a), (8b), so too will the limiting forms of the budget shares, $s_{ih}$[4]. A test of the joint insignificance of the $\delta_i$'s, thus, constitutes a test of the hypothesis that the item-wise budget shares of the 'poor' and 'rich' households are invariant to the total number of children in these households.

In the empirical application that is reported below, we choose the following functional forms for $P_1, P_2$:

$$ln P_1 = \sum_i \alpha_i ln p_i, \quad \sum_i \alpha_i = 1 \qquad (10a)$$

$$ln P_2 = \sum_i \beta_i ln p_i, \quad \sum_i \beta_i = \eta \qquad (10b)$$

$P_1$ can be interpreted as the subsistence expenditure of a single adult, childless household, similar to the interpretation given to $a(\mathbf{p})$ in the AIDS/QAIDS context. However, unlike in (2a), we had to choose a simple Cobb Douglas form in (10a) since we found it impossible to achieve convergence in the demand estimation of (9) with CES type generalisation or the use of cross-product in logs as in (2a).

(10a), (10b), in conjunction with (9), yield the following estimable form for DMMAIDS in budget share terms:

$$s_{ih} = \frac{(\alpha_i + \delta_i z_h) + (\beta_i + \eta \delta_i z_h) R_h}{1 + \eta R_h} \qquad (11)$$

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[4] A more complex specification of the price sensitivity of the equivalence scale deflator will allow the limits of $w_{1h}, w_{2h}$ to depend on the age distribution of children as well.

where $R_{hi} (= lnx_{hi} - lnm_{0hi} - lnP_{hi})$ is the log of real expenditure per adult equivalent, and $m_{0hi}(z_h, \varphi)$ is given by (4). Eqn. (11) is similar to the Gorman (1976) demographic specification in allowing sophisticated demographic effects. As with the Gorman (1976) model, in the DMMAIDS model, given by eqn. (11), the number of children, $z_h$, affects the budget shares through the real expenditure per adult equivalent variable, $R_h$, and its coefficient, $(\beta_i + \eta \delta_i z_h)$. The latter effect is missing in case of the AIDS model which assumes $\eta = 0$. There is also a fixed cost demographic effect through the subsistence budget share $(\alpha_i + \delta_i z_h)$. The addition of a child has a lateral effect on the item-wise budget shares of a subsistence household $(R_h = 0)$ similar to that in the QAIDS model. As we turn to the empirical results, it is worth noting that several of the parameters have similar interpretations in the PS-QAIDS and DMMAIDS models, making a comparison of their estimates of some interest.


## 3. DATA SETS AND DEMOGRAPHIC DEMAND ESTIMATES

The estimation and analysis are based on a pooled cross-section of the unit record files from the Household Expenditure Survey (HES) conducted by the ABS for the years 1988/9, 1993/4, 1998/9 and 2003/4. The household is chosen as the unit of analysis. The estimation and analysis was based on the full sample of 29463 observations over the four HES data sets (7225 households in 1988, 8389 in 1993, 6892 in 1998 and 6957 in 2003). The following 9 item breakdown of household expenditure was used: Accommodation ($i$=1); Electricity and Household Fuel ($i$=2); Food and Non-alcoholic Beverages ($i$=3); Alcohol and Tobacco ($i$=4); Clothing and Footwear ($i$=5); Health and Personal Care ($i$=6); Transport ($i$=7); Recreation ($i$=8); and Miscellaneous items including Credit Charges and Education ($i$=9). The price series used was based on the ABS (2008a) Consumer Price Index quarterly series by Groups, Sub-groups and Expenditure Class but re-weighted using ABS(2005) to match the HES Commodity List. The constructed price series was matched with each quarter and state/territory that the HES was carried out in and based at the end of the second quarter of 1988. Children were split into the following three age groups: children under 5 years of age ($z_1$), those aged between 5 and 14 years ($z_2$) and the number of dependents or students aged 15 to 23 years ($z_3$).

Tables 1 and 2 present the parameter estimates of the demographic demand systems, namely, the PS-QAIDS and DMMAIDS demand models. Both these models represent significant improvements over the nested AIDS model. This is evident from the strong statistical significance of the quadratic coefficients, $\lambda_i s$, in the case of the PS-QAIDS and $\eta$[5] in the case of the DMMAIDS model. The demographic effects are, also, highly significant in most cases. Both the models agree that household behaviour exhibits significant economies of scale with the $\theta$ estimate being significantly different from zero in both cases. The estimates of the parameters that scale household expenditure ($\rho_g$) are remarkably robust between the two demand systems. The $\partial_i s$, which show the sensitivity of the overall equivalence scale to prices are, also, highly significant and robust between the two demand systems. Using the alternative interpretation of the $\partial_i s$ discussed above, both the demand models agree that the marginal addition of a child increases the budget share of Food and decreases that of Alcohol and Tobacco for a household living at subsistence level.

Notwithstanding the fact that DMMAIDS is considerably more parsimonious in parameters than the PS-QAIDS, the log likelihood is only marginally lower so that, on Akaike criterion, DMMAIDS is the preferred model. Tables 3 and 4 present the expenditure and price elasticities implied by the two sets of demand estimates, and calculated at the sample means in the 2003/4 HES and at 2003/4 prices. The expenditure elasticites are fairly robust between the two demand systems but this does not extend to the price elasticities. The DMMAIDS price elasticities are generally more plausible than the PS-QAIDS elasticities with the latter recording positive own price elasticities for item 2 (Electricity and Household Fuel) and item 9 (Miscellaneous, Credit Charges and Education).

The Engel curves corresponding to the two sets of demand estimates are presented in Figs 1-9. Each figure compares the Engel curves between the PS-QAIDS and DMMAIDS models. The shape of the Engel curves is generally robust with the significant exceptions being Clothing and Footwear ($i$=5) and Health and Personal care ($i$=6). Clothing illustrates an advantage of the PS-QAIDS over the DMMAIDS since the non-monotonic relationship between budget share and aggregate expenditure – permitted by the former but not the latter – allows the Engel curve of this item to bend backwards. In contrast to Clothing, there is remarkable similarity between the two Engel curves in case of Electricity and Household

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[5] The estimate of $\eta$, which represents the generalisation of MAIDS over AIDS is highly sensitive to demographic effects, increasing from 0.44 for DMMAIDS to 0.73 for MAIDS.

Fuel, especially in the lower expenditure levels. In general, while the two curves track one another quite closely in the middle expenditure ranges, wide differences open up at the two extremes of the expenditure spectrum. For example, in relation to DMMAIDS, PS-QAIDS understates the predicted budget share of Food quite substantially at the higher expenditure levels. More seriously, since a cut off level of budget share of Food is often used, (based on Engel's law) to define the poverty line [see Lancaster, Ray and Valenzuela (1999)], the sharp divergence between the two Engel curves for Food at the lower expenditure levels has significant implications for poverty enumeration and identification of "food insecure" households. If one adopts a Food budget share cut off of 0.5 or higher, then the DMMAIDS model yields a much higher poverty line and a larger number of food insecure households than the PS-QAIDS model. The graphs also show that the concern expressed by the MAIDS authors, Cooper and McLaren (1992) over the PIGLOG based models yielding predicted budget shares that lie outside the (0,1) range appears misplaced since in all cases they are well within the range.

## 4. THE DISTRIBUTIONAL IMPLICATIONS OF PRICE MOVEMENTS IN AUSTRALIA

This section illustrates the policy usefulness of the demographic demand estimates, presented earlier, in evaluating the distributional implications of relative price movements in Australia. Inflation that is accompanied by a significant change in the relative prices of the principal items of consumption affects the various household groups differently due to differences in their expenditure pattern. For example, Muellbauer (1974) shows that "relative consumer price changes in the U.K. since 1964 have had an inequality increasing bias". Ray (1985) extended Muellbauer (1974)'s methodology to allow non-linear Engel curves, while continuing to work with rank 2 preferences that assume a monotonic relationship between budget share and aggregate expenditure.

In this section, we extend the methodology further by working within the framework of rank 3 demand systems. The PS-QAIDS has a definite edge over DMMAIDS in this welfare application since, besides allowing independence between the linear and quadratic expenditure coefficients in the budget share equation, PS-QAIDS has an explicit cost function representation that makes it suitable for analysis of the distributional implications of

relative price changes. The DMMAIDS, which defines the expenditure function only implicitly, is handicapped in this respect.

A comparison of the nominal and real expenditure inequalities throws light on the inequality implications of price movements. The PS-QAIDS cost function of household $h$ in year $t$ is given as follows:

$$\ln c_{ht}(u, p, z) = \ln x_{ht}$$
$$= \ln m_h(z_h, p_t) + \ln a(p_t) + \frac{u_t b(p_t)}{1 - u_t c(p_t)} \qquad (12)$$

where $x_{ht}$ is the nominal expenditure of the household and $u_t$ is the utility measure in year $t$. Following Muellbauer (1974, pg 42), we define real equivalent expenditure of household $h$ in year $t$, $\tilde{x}_{ht}$, as the minimum expenditure needed to obtain current year utility, $u_t$ at base year price, $p_0$. In other words:

$$\tilde{x}_{ht} = c(p_0, u_t, z_h) \qquad (13)$$

The application of (13) in (12) yields, after some rearrangement, the following expression for real expenditure in the PS-QAIDS case:

$$\tilde{x}_{ht} = \bar{m}_h(z_1, \ldots, z_G) \prod_k p_{kt}^{\delta_k z_h} a_0 exp \left| \frac{b_0}{\left( c_0 + \frac{b_t}{\ln x_t - \ln a_t - \ln \bar{m} - \sum_k \delta_k z_h \ln p_{kt}} - c_0 \right)} \right| \qquad (14)$$

where $\bar{m}_h = (n a_h + \sum_{g=1}^{G} \rho_g z_{gh})^{1-\delta}$ is the price invariant component of the equivalence scale, and $a_t, b_t, c_t$ are given in (2a)-(2c), evaluated at year $t$. It is readily verified from (14) that in the base year the real and nominal expenditures are equal (i.e. $\tilde{x}_{h0} = x_{h0}$ ) and consequently, the nominal and real expenditure inequalities will coincide. The magnitude and sign of the difference between the inequalities in real and nominal expenditures per adult equivalent, i.e. between the inequalities in $\tilde{y}_{ht}(= \tilde{x}_{ht}/m_{0h})$ and $y_{ht}(= x_{ht}/m_{0h})$ will, therefore, depend not only on the price vector in the given year but also on the estimated PS-QAIDS parameters that will determine the $a_t, b_t,$ and $c_t$ values. A comparison of the real $(I_t^R)$ and nominal $(I_t^N)$ expenditure inequalities in year t reveals the nature of inequality bias in the relative price movements. $(I_t^R - I_t^N) > 0$ implies that the relative price movement has been inegalitarian or inequality increasing, while the reverse is indicated if $(I_t^R - I_t^N) < 0$.

Table 5 presents the nominal and real expenditure inequalities based on the PS-QAIDS parameter estimates of Table 1. The inequality estimates were calculated using the Gini and Atkinson inequality measures with the latter evaluated at two levels of 'inequality aversion', $\varepsilon$. Table 5 confirms that, after an initial decline in the early1990s, there has been an increase in expenditure inequality that accelerated sharply during the period 1998/99-2003/4[6] which coincides with the introduction of GST in Australia in 2000. Moreover, the larger magnitude of real expenditure inequality over nominal expenditure inequality points to the inequality increasing nature of the price movement since 1993/94. These findings are robust to the choice of the measure used in the expenditure inequality calculations. The inequality increasing nature of the price movements in Australia is seen more clearly from Fig.10 which presents the Lorenz curves of per equivalent adult expenditures, in nominal and real terms, in 2003/4. The Lorenz curve of real expenditure lies outside that of nominal expenditure, and a large gap exists between the two distributions, especially over the middle expenditure range.

## 5. CONCLUDING REMARKS

The recent turmoil in the world's financial markets and attempts to revive falling consumer demand in the midst of recessionary trends have highlighted the importance of reasonably accurate estimates of demand responses to changes in income and prices. This has put the focus of much of applied research back on the specification and estimation of demand systems in order to obtain updated and reliable estimates of price and expenditure/income elasticities. As Slottje (2008) says, "the current state of many global economies and the importance of consumer expenditures in fuelling these economies make it imperative that new research 'demand tools' be developed and used by economists and policy makers to deal with increasingly complex issues that arise out of troubling economic trends" (p.207). The present study that proposes and estimates two new demographic demand models on Australian household expenditure data, was undertaken in this spirit.

While demand systems estimation has traditionally been performed on time series of consumer expenditure and prices obtained from national accounts data, in recent years, with the increasing availability of cross sectional household expenditure surveys – often in the form of unit records – the data base has typically been pooled time series of budget surveys

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[6] See Blacklow and Ray (2000) for inequality movement in the earlier period, 1975/76 to 1988/89.

containing variation in prices, aggregate household expenditure, household size and composition. The need to allow the simultaneous movement in these exogenous determinants of expenditure allocation in the demand estimation has prompted the move to demographic demand systems. This paper contributes to this trend by proposing a demographic demand procedure and applying it to two recent demand functional forms to generate their demographic extensions. The empirical results illustrate the usefulness of the demographic demand procedure by providing sensible and robust estimates of the equivalence scales, economies of household size and the price and expenditure elasticities, all of which are required in a host of policy applications that range from poverty measurement to the design and reform of commodity taxes. A particularly useful aspect of the proposed demographic procedure is that its empirical application yields precise and robust estimates of the nature and magnitude of the variation of the equivalence scale with the relative prices of the various subgroups of expenditure items. A significant result in this context is the conclusion that, over the period of this study, namely 1988-2003, the equivalence scale, which is used as the household size deflator, has changed considerably in response to the relative price changes.

The policy usefulness of this exercise is further illustrated by using the equivalence scale and demand parameter estimates to analyse the distributional implications of price movements in Australia. The paper builds on the existing literature by proposing and applying a methodology for evaluating the nature and magnitude of the inequality bias of relative price changes. The findings of this study that during the period, 1998-2003, the price movements in Australia had an inequality increasing bias, against a background of rising nominal expenditure inequality, is a result of policy significance.

The "unitary household" model, adopted in this study can be relaxed in favour of "collective household" models that allow intra-household interaction in decision making by various household members [see, for example, Lewbel and Pendakur (2008)]. The extension of the demographic demand procedure proposed here to the "collective household" framework and the examination of the robustness of the empirical evidence to such an extension is a fruitful area for further research.

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TABLE 1: PS-QUAIDS Parameter Estimates*

| Param | Value | Param | Value | Param | Value | Param | Value | Param | Value |
|---|---|---|---|---|---|---|---|---|---|
| $\alpha_1$ | 0.993 (0.00) | $\beta_1$ | -0.238 (0.00) | $\rho_1$ | 0.589 (0.00) | $\gamma_{27}$ | -0.056 (0.00) | $\gamma_{57}$ | 0.014 (0.35) |
| $\alpha_2$ | 0.492 (0.00) | $\beta_2$ | -0.141 (0.00) | $\rho_2$ | 0.650 (0.00) | $\gamma_{28}$ | 0.060 (0.00) | $\gamma_{58}$ | 0.022 (0.16) |
| $\alpha_3$ | 0.303 (0.00) | $\beta_3$ | 0.046 (0.00) | $\rho_3$ | 0.629 (0.00) | $\gamma_{29}$ | -0.052 (0.00) | $\gamma_{59}$ | -0.010 (0.46) |
| $\alpha_4$ | -0.216 (0.00) | $\beta_4$ | 0.104 (0.00) | $\theta$ | 0.444 (0.00) | $\gamma_{33}$ | 0.069 (0.00) | $\gamma_{66}$ | -0.052 (0.00) |
| $\alpha_5$ | -0.194 (0.00) | $\beta_5$ | 0.075 (0.00) | $\gamma_{11}$ | -0.007 (0.84) | $\gamma_{34}$ | -0.045 (0.00) | $\gamma_{67}$ | 0.043 (0.00) |
| $\alpha_6$ | -0.125 (0.00) | $\beta_6$ | 0.081 (0.00) | $\gamma_{12}$ | -0.154 (0.00) | $\gamma_{35}$ | -0.036 (0.00) | $\gamma_{68}$ | -0.009 (0.28) |
| $\alpha_7$ | 0.063 (0.09) | $\beta_7$ | -0.032 (0.02) | $\gamma_{13}$ | -0.010 (0.61) | $\gamma_{36}$ | -0.032 (0.00) | $\gamma_{69}$ | 0.013 (0.28) |
| $\alpha_8$ | -0.323 (0.00) | $\beta_8$ | 0.119 (0.00) | $\gamma_{14}$ | 0.160 (0.00) | $\gamma_{37}$ | 0.007 (0.65) | $\gamma_{77}$ | -0.063 (0.03) |
| $\alpha_9$ | 0.008 (0.72) | $\beta_9$ | -0.014 (0.06) | $\gamma_{15}$ | 0.043 (0.01) | $\gamma_{38}$ | 0.047 (0.00) | $\gamma_{78}$ | 0.025 (0.20) |
| $\lambda_1$ | 0.019 (0.00) | $\delta_1$ | -0.001 (0.11) | $\gamma_{16}$ | 0.012 (0.27) | $\gamma_{39}$ | -0.034 (0.16) | $\gamma_{79}$ | 0.033 (0.27) |
| $\lambda_2$ | 0.010 (0.00) | $\delta_2$ | 0.000 (0.12) | $\gamma_{17}$ | 0.008 (0.73) | $\gamma_{44}$ | -0.038 (0.00) | $\gamma_{88}$ | -0.039 (0.11) |
| $\lambda_3$ | -0.011 (0.00) | $\delta_3$ | 0.007 (0.00) | $\gamma_{18}$ | -0.035 (0.11) | $\gamma_{45}$ | -0.041 (0.00) | $\gamma_{89}$ | -0.035 (0.15) |
| $\lambda_4$ | -0.010 (0.00) | $\delta_4$ | -0.007 (0.00) | $\gamma_{19}$ | -0.017 (0.36) | $\gamma_{46}$ | -0.010 (0.02) | $\gamma_{99}$ | 0.138 (0.00) |
| $\lambda_5$ | -0.006 (0.00) | $\delta_5$ | 0.004 (0.00) | $\gamma_{22}$ | -0.001 (0.68) | $\gamma_{47}$ | -0.010 (0.33) | | |
| $\lambda_6$ | -0.008 (0.00) | $\delta_6$ | -0.005 (0.00) | $\gamma_{23}$ | 0.033 (0.00) | $\gamma_{48}$ | -0.035 (0.00) | | |
| $\lambda_7$ | 0.008 (0.00) | $\delta_7$ | -0.002 (0.00) | $\gamma_{24}$ | 0.054 (0.00) | $\gamma_{49}$ | -0.035 (0.01) | | |
| $\lambda_8$ | -0.007 (0.00) | $\delta_8$ | -0.004 (0.00) | $\gamma_{25}$ | 0.051 (0.00) | $\gamma_{55}$ | -0.010 (0.53) | | |
| $\lambda_9$ | 0.004 (0.00) | $\delta_9$ | -0.222 0.000 | $\gamma_{26}$ | 0.065 (0.00) | $\gamma_{56}$ | -0.031 (0.00) | | |

Log-likelihood: 275998.9        Parameters estimated: 72        Observations: 29463

*Figures in parenthesis denote p-values.

TABLE 2: Demographically Modified MAIDS Parameter Estimates*

| | | | | | |
|---|---|---|---|---|---|
| $\alpha_1$ | 0.795 (0.00) | $\beta_1$ | 0.033 (0.00) | $\delta_1$ | -0.002 (0.00) |
| $\alpha_2$ | 0.592 (0.00) | $\beta_2$ | -0.084 (0.00) | $\delta_2$ | -0.001 (0.01) |
| $\alpha_3$ | 1.525 (0.00) | $\beta_3$ | -0.152 (0.00) | $\delta_3$ | 0.008 (0.00) |
| $\alpha_4$ | 0.029 (0.00) | $\beta_4$ | 0.026 (0.00) | $\delta_4$ | -0.006 (0.00) |
| $\alpha_5$ | -0.204 (0.00) | $\beta_5$ | 0.061 (0.00) | $\delta_5$ | 0.004 (0.00) |
| $\alpha_6$ | 0.229 (0.00) | $\beta_6$ | 0.004 (0.02) | $\delta_6$ | -0.005 (0.00) |
| $\alpha_7$ | -0.866 (0.00) | $\beta_7$ | 0.243 (0.00) | $\delta_7$ | -0.003 (0.00) |
| $\alpha_8$ | -0.607 (0.00) | $\beta_8$ | 0.182 (0.00) | $\delta_8$ | -0.004 (0.00) |
| $\alpha_9$ | -0.493 (0.00) | $\beta_9$ | 0.127 (0.00) | $\delta_9$ | 0.009 (0.00) |
| | | | | $\rho_1$ | 0.607 (0.00) |
| | | | | $\rho_2$ | 0.662 (0.00) |
| | | | | $\rho_3$ | 0.646 (0.00) |
| | | | | $\theta$ | 0.455 (0.00) |
| | | | | $\eta$ | 0.439 (0.00) |

Log-likelihood: 273999     Parameters estimated: 29     Observations: 29463

*Figures in parenthesis denote p-values.

## TABLE 3: PS-QAIDS Elasticities

**Expenditure Elasticities** ($e_i$)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| 0.904 | 0.146 | 0.515 | 0.882 | 1.507 | 0.880 | 1.410 | 1.394 | 1.444 |

**Price Elasticities** ($e_{ij}$)

| i/j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | **-0.349** | -0.158 | -0.149 | 0.279 | -0.070 | -0.157 | 0.131 | -0.406 | -0.024 |
| 2 | -1.485 | **1.644** | 0.774 | 0.244 | 0.659 | 1.195 | -1.621 | 0.239 | -1.794 |
| 3 | -0.187 | 0.102 | **-0.283** | -0.105 | -0.113 | -0.058 | -0.036 | 0.416 | -0.250 |
| 4 | 2.059 | 0.170 | -0.571 | **-1.039** | -0.401 | 0.506 | -0.644 | 0.131 | -1.092 |
| 5 | -0.794 | 0.542 | -0.859 | -0.562 | **-0.640** | -0.437 | 0.189 | 1.468 | -0.414 |
| 6 | -0.655 | 0.423 | -0.227 | 0.278 | -0.164 | **-1.422** | 0.487 | 0.308 | 0.092 |
| 7 | 0.133 | -0.361 | -0.189 | -0.207 | 0.046 | 0.229 | **-1.430** | 0.065 | 0.303 |
| 8 | -1.218 | 0.043 | 0.440 | 0.010 | 0.426 | 0.151 | 0.085 | **-0.931** | -0.401 |
| 9 | -0.281 | -0.743 | -0.790 | -0.674 | -0.199 | 0.064 | 0.608 | -0.681 | **1.252** |

## TABLE 4: Demographically Modified MAIDS Elasticities

**Expenditure Elasticities** ($e_i$)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| 0.905 | -0.132 | 0.653 | 1.025 | 1.316 | 0.882 | 1.445 | 1.353 | 1.481 |

**Price Elasticities** ($e_{ij}$)

| i/j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | **-0.925** | 0.056 | 0.145 | 0.002 | -0.019 | 0.021 | -0.082 | -0.058 | -0.046 |
| 2 | 0.898 | **-0.331** | 1.731 | 0.029 | -0.228 | 0.256 | -0.981 | -0.689 | -0.551 |
| 3 | 0.275 | 0.205 | **-0.469** | 0.009 | -0.07 | 0.078 | -0.301 | -0.211 | -0.169 |
| 4 | -0.02 | -0.015 | -0.039 | **-1.001** | 0.005 | -0.006 | 0.022 | 0.015 | 0.012 |
| 5 | -0.251 | -0.187 | -0.484 | -0.008 | **-0.936** | -0.072 | 0.274 | 0.192 | 0.154 |
| 6 | 0.093 | 0.07 | 0.18 | 0.003 | -0.024 | **-0.973** | -0.102 | -0.072 | -0.057 |
| 7 | -0.352 | -0.263 | -0.68 | -0.011 | 0.09 | -0.1 | **-0.615** | 0.271 | 0.216 |
| 8 | -0.28 | -0.209 | -0.54 | -0.009 | 0.071 | -0.08 | 0.306 | **-0.785** | 0.172 |
| 9 | -0.381 | -0.284 | -0.734 | -0.012 | 0.097 | -0.109 | 0.416 | 0.292 | **-0.766** |

## TABLE 5: Nominal and Real Expenditure Inequalities[^]

| | NOMINAL | | | REAL | | |
|---|---|---|---|---|---|---|
| | | Atkinson | | | Atkinson | |
| Year | GINI | $\varepsilon = 0.5$ | $\varepsilon = 2$ | GINI | $\varepsilon = 0.5$ | $\varepsilon = 2$ |
| 1988/9 | 0.308 | 0.076 | 0.287 | 0.308 | 0.076 | 0.286 |
| 1993/4 | 0.302 | 0.073 | 0.270 | 0.309 | 0.076 | 0.276 |
| 1998/9 | 0.306 | 0.075 | 0.278 | 0.317 | 0.080 | 0.287 |
| 2003/4 | 0.315 | 0.080 | 0.297 | 0.361 | 0.105 | 0.364 |

^ $\varepsilon$ denotes 'inequality aversion'

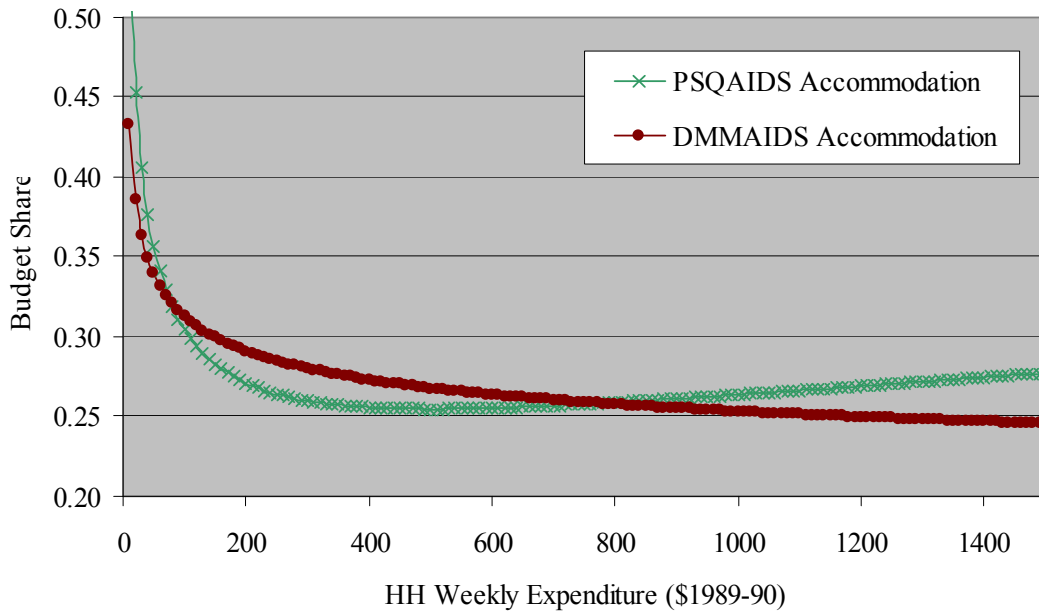FIGURE 1: BUDGET SHARES FOR ACCOMODATION



FIGURE 2: BUDGET SHARES FOR ELECTRICITY AND HOUSEHOLD FUEL
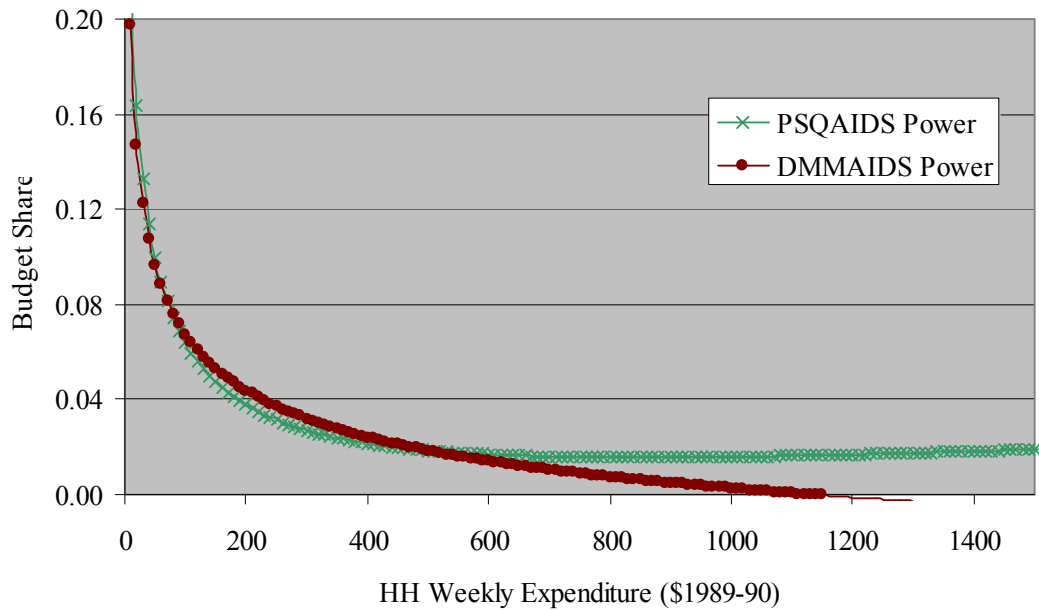
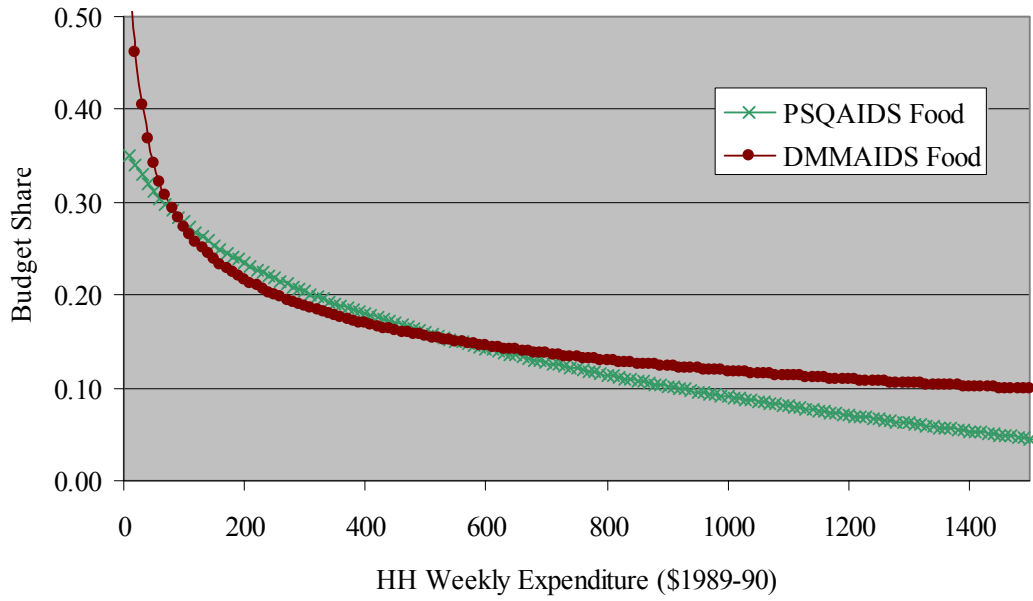## FIGURE 3: BUDGET SHARES FOR FOOD



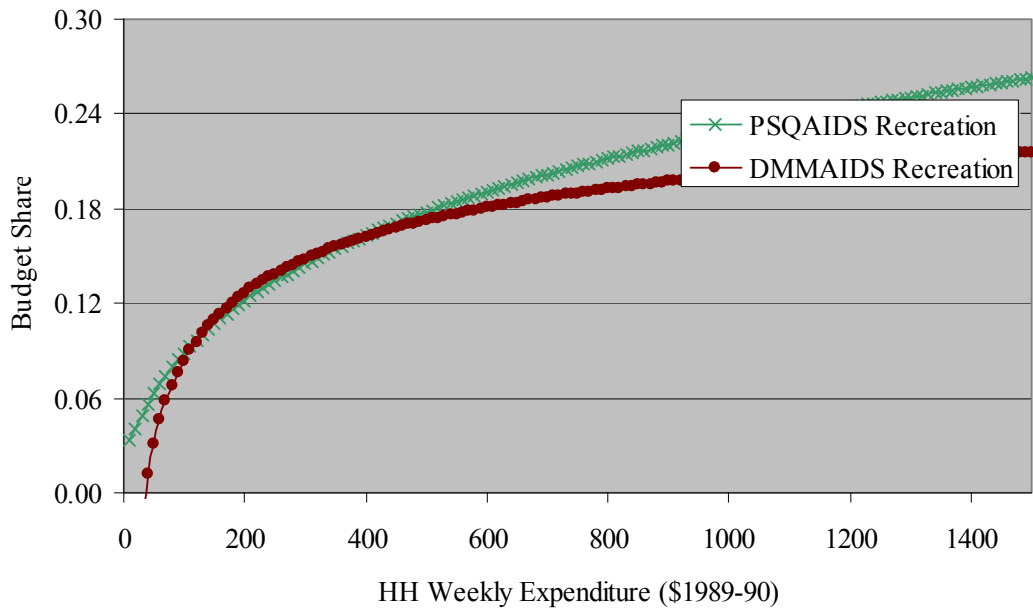## FIGURE 4: BUDGET SHARES FOR ALCOHOL & TOBACCO

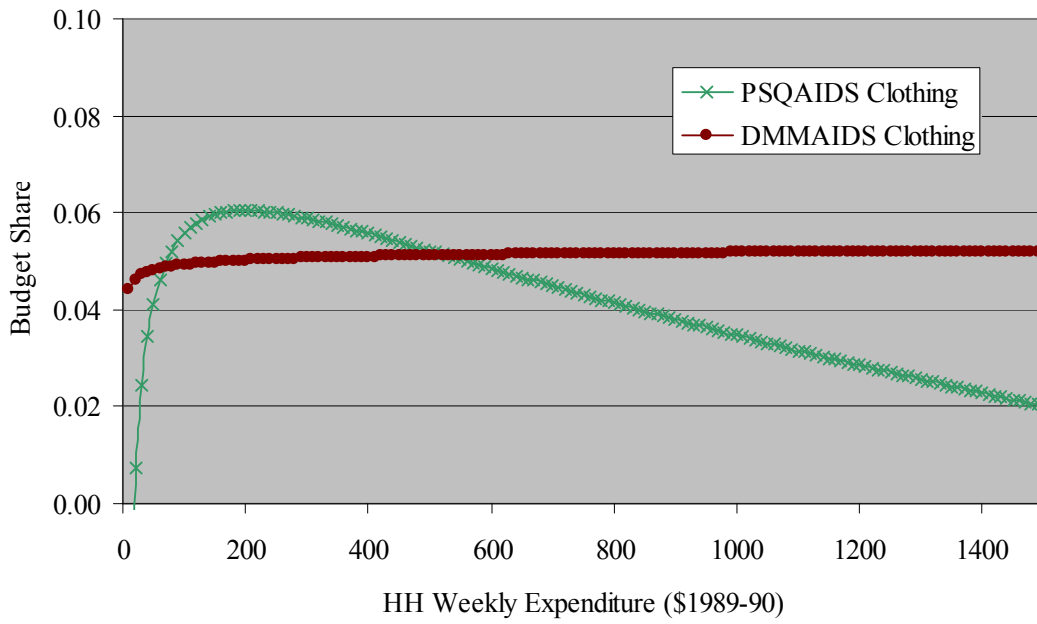FIGURE 5: BUDGET SHARES FOR CLOTHING
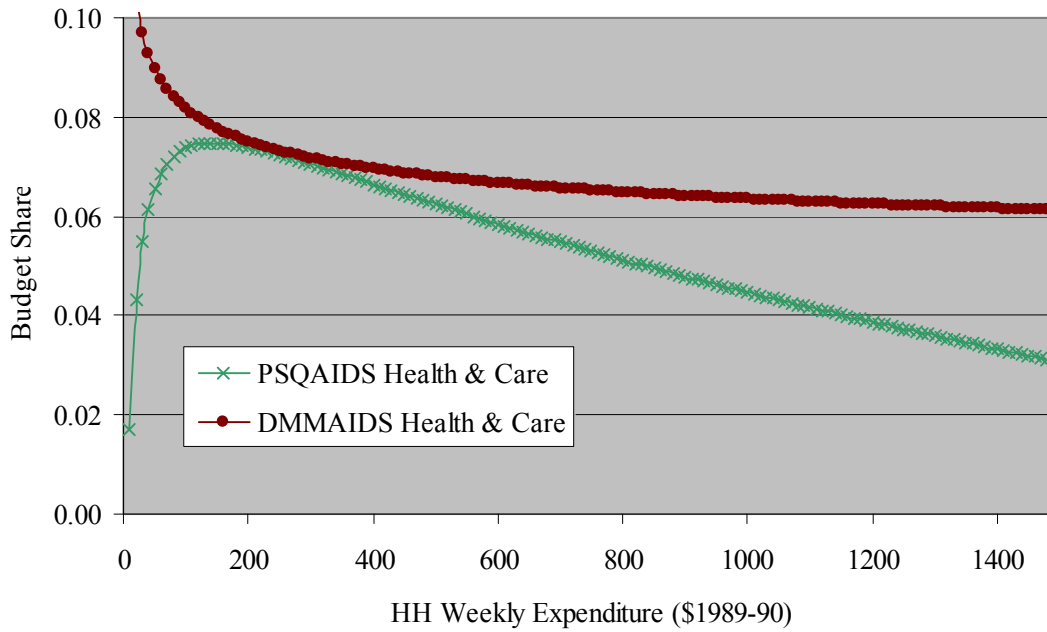


FIGURE 6: BUDGET SHARES FOR HEALTH

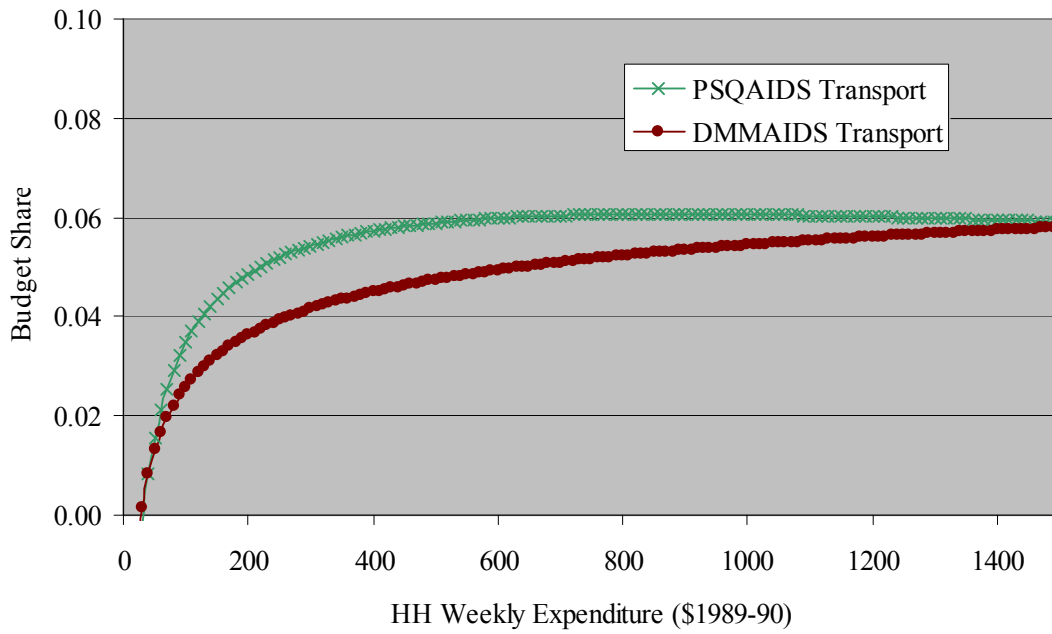## FIGURE 7: BUDGET SHARES FOR TRANSPORT



## FIGURE 8: BUDGET SHARES FOR RECREATION
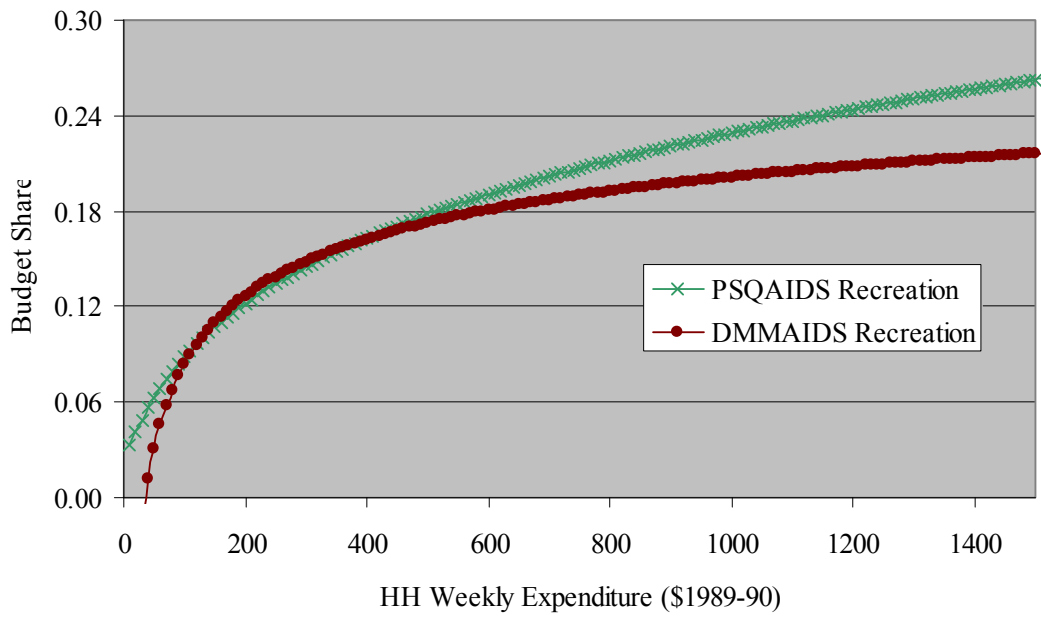
FIGURE 9: BUDGET SHARES FOR EDUCATION, CREDIT AND MISCELLANEOUS
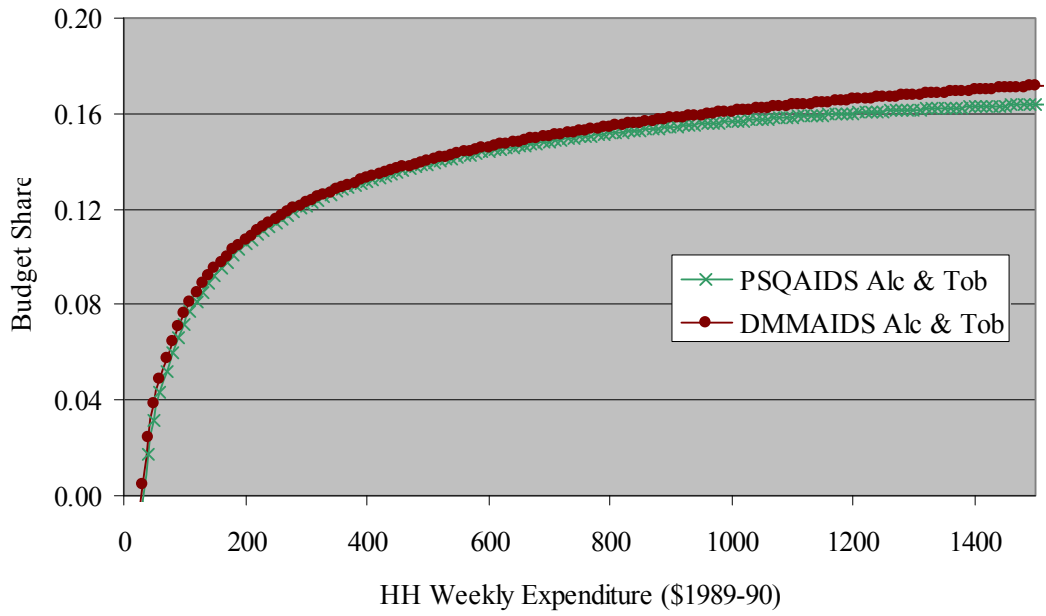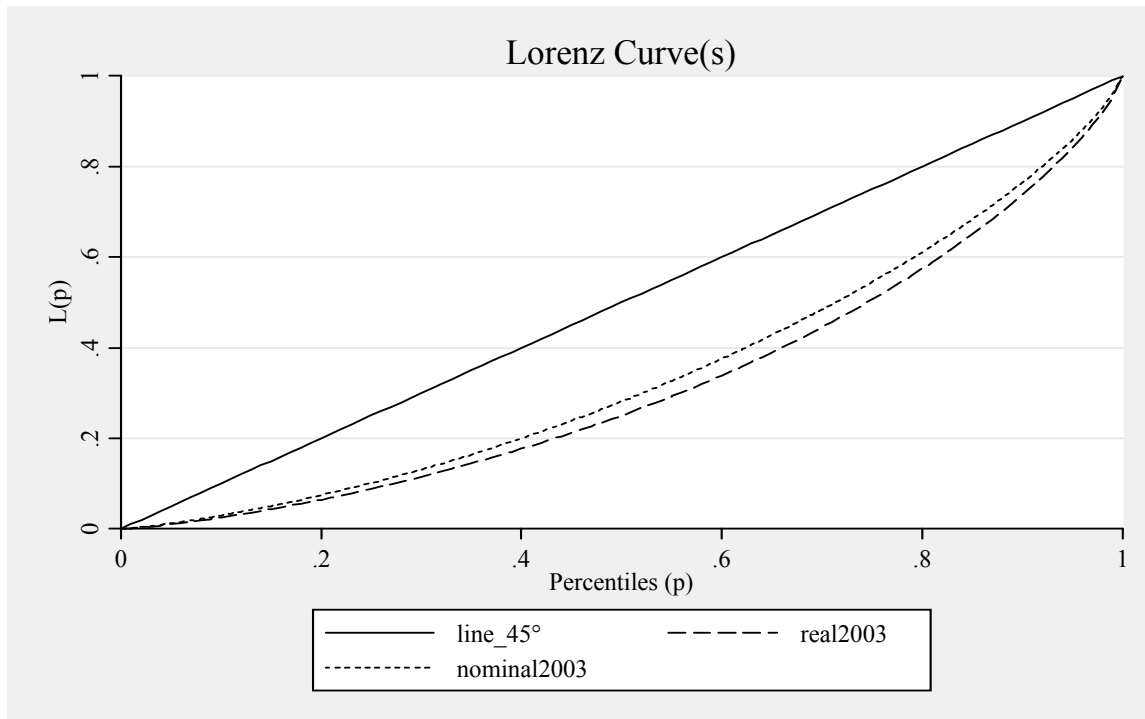SPENDING



FIGURE 10: Lorenz Curves of Nominal and Real Expenditures in 2003/4

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